Stable Operating Limits for Amine Absorbers

The most economical way to operate an absorber is usually with just the minimum solvent rate necessary to absorb the required amount of acid gases, i.e., just to meet the specifications on the treated gas. If, for example, an absorber's performance is being determined by the solvent lean loading, the column is called lean-end pinched and it may well be possible to operate this column using a lower solvent flow rate. The proviso, however, is that the solvent flow rate must be high enough that sufficient capacity is available to absorb the quantity of acid gases needed.

We will look at three ProTreat™ simulation cases of absorbers as solvent rate is turned down: (1) a selective treater using MDEA, and removal of CO_2 using (2) MEA and (3) piperazine-activated MDEA. The precise details of these three cases are not important. What matters is the way in which performance changes as solvent rate is reduced below a "safe" value. A lot can be learned from looking at the absorber temperature profiles.

Figure 1 shows how the temperature profile in the selective absorber responds to changing solvent rate. When the temperature peaks near the bottom of the absorber (210 gpm), there is enough
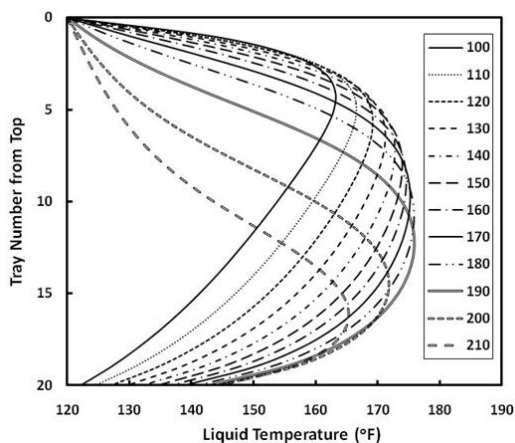

Figure 2   Effect of Solvent Rate on MDEA Treating

Figure 1   Effect of Solvent Rate on Temperature Profiles in a Selective MDEA Absorber

solvent to keep the contactor lean-end pinched and treating at <4 ppmv H_2S (Figure 2). But as the solvent flow is reduced, the H_2S in the treated gas starts to rise quite rapidly, and by 200 gpm there is barely enough solvent to remove the required amount of acid gases. (Much of the acid gas being absorbed is actually CO_2 and this reduces the solvent capacity for H_2S.) The acid gas that is in excess of the solvent's capacity simply passes through the absorber and exits with the treated gas. Another term for this is acid gas "breakthrough".

In the vicinity of breakthrough, ProTreat shows the column gets harder to control because small fluctuations in such parameters as solvent flow, raw gas flow, and raw gas composition will cause changes in treating tens of times larger than the original fluctuation. Process fluctuations do not cause catastrophic effects—the absorber just becomes harder (but not impossible) to operate and to control near minimum solvent rate. Controllability is much more problematic; however, when the solvent is highly-reactive towards CO_2, such as when MEA or a piperazine promoted MDEA is used for deep CO_2 removal.

Figure 3 shows a typical treating response curve for MEA used to remove 5% CO_2 from a gas. Here we see that treating responds much faster in the vicinity of the minimum solvent rate. The

ProTreat-simulated temperature profiles in Figure 4 show a precipitous change between 230 and 240 gpm. The column goes from lean-end to rich-end pinched with only a 10 gpm (4%) change in solvent rate! Residual CO_2 goes from 10 ppmv to 300 ppmv, a disaster in an LNG plant.
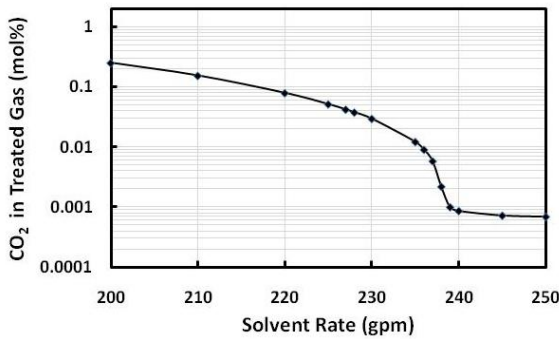

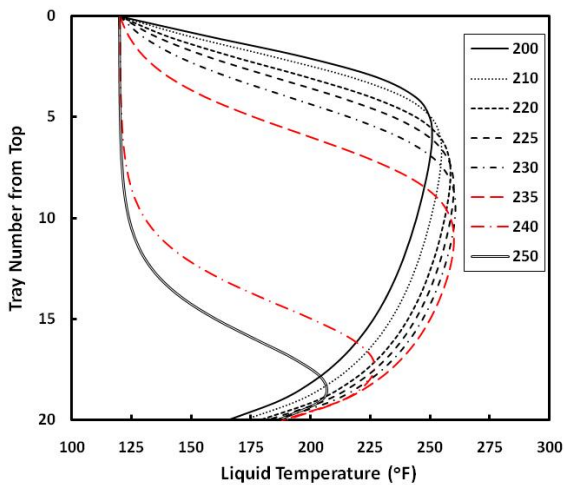**Figure 3   Effect of Solvent Rate on Treating with MEA**

Figure 4   Effect of Solvent Rate on Temperature Profiles in CO_2 Removal with MEA

Piperazine promoted MDEA has been used for over 25 years to remove CO_2 from synthesis gases down to <1,000 ppmv and more recently for very deep removal in LNG applications. This final example applies ProTreat™ simulation of 7 wt% piperazine with 33 wt% MDEA to reduced CO_2 in 16 bar(g) natural gas from 20% to only a few ppmv.

Figure 5 shows that in the vicinity of minimum solvent rate, a 1% decrease in solvent flow from 89% to 88% of the design rate causes the CO_2 in the treated gas to rise from 1 ppmv to 2,000 ppmv. At 88.9% of design flow this column is operating right on the edge of a very steep cliff; at 88.8% it has fallen over the edge. Figure 6 shows how the temperature profile responds.

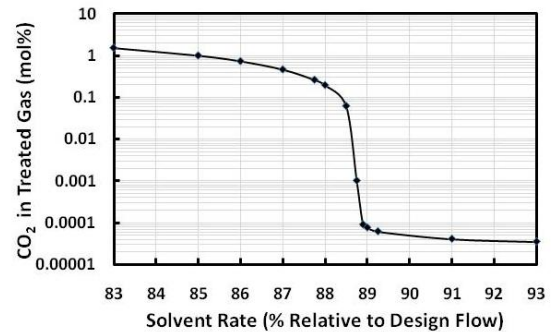The extraordinary sensitivity to solvent rate in this packed tower is caused by the very fast

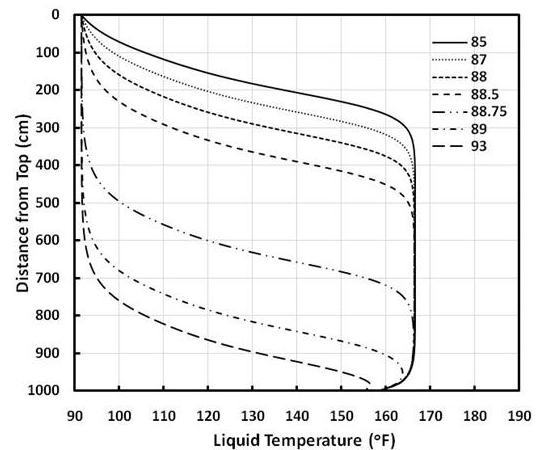**Figure 5   Treating with Piperazine Promoted MDEA**

Figure 6   Effect of Solvent Rate on Temperature Profiles with Piperazine Promoted MDEA

chemical kinetics of the piperazine-CO_2 reaction.

Gas-phase CO_2 profiles look very similar to the temperature profiles in Figure 6. The bulk of the absorption and reaction takes place in a 1–2 m deep zone with a 2–3 meter polishing zone above. But above the polishing zone the rest of the column does nothing. The position of these two zones moves up and down the column with very small decreases and increases in solvent flow rate. CO_2 breakthrough occurs suddenly and without warning, and it's almost independent of the amount of packing in the column.

Solvents with very fast CO_2 kinetics can produce highly unstable absorber operation if one tries to operate too close to minimum solvent rate.

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To learn more about this and other aspects of gas treating, attend one of our workshops in Houston, or this year Winterthur, Switzerland and Abu Dhabi, UAE. Visit www.ogtrt.com/seminars for details.

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